Quantifying Prehistoric Grave Wealth

Mikkel Nørtoft[1,2,3,*]

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Abstract

Quantifying wealth in prehistoric graves is a long-standing unresolved issue. Previous approaches have either focused on only one or a few aspects of grave wealth or grave good value, e.g. scarcity, or total number of object types (TOT), thus neglecting other value aspects, or, if combining value parameters, not in a reproducible or transparent way which makes application or comparison with other cases difficult. This study presents a new method of combining different aspects of grave good wealth from value aspects such as manufacturing time and skill, case-specific scarcity, prestige, and raw material distance value measures, as well as estimated meat consumption from animal bones, all equally weighted and combined with applied Gini index. This Gini index can then be combined with Gini indices from more general grave wealth measures, including TOT and grave pit depth to form a more balanced Gini index of general grave wealth. All of these parameters are calculated in a flexible and semi-automated framework based on experimental and prehistoric crafts reference data, which can be continuously updated and fine-tuned, flexibly integrates the respective chaînes operatoires, and which is openly available. As a case study, the framework was applied to a dataset of 81 graves from 46 sites of the Corded Ware Culture in Moravia, Czech Republic.

[1] Department of Prehistoric Archaeology
[2] Saxo Institute - University of Copenhagen
[3] Denmark

[*] Correspondence: Mikkel Nørtoft <jsv399@hum.ku.dk>

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Highlights: New open framework for quantification of grave wealth combining a range of different grave good value and grave wealth aspects; Comparison of Gini indices for prehistoric house and grave data.

1 Introduction

Wealth may be defined in different ways in a given society, and may have varying focus in different economies, regions and periods. A general framework for characterizing main wealth types based on a comparative analysis of ethnographic data has been proposed by Mulder et al. (2009) and Smith et al. (2010), summarized in Smith, Kohler and Feinman (2018). This includes embodied wealth (e.g. body weight, grip strength, practical skills, and reproductive success), relational wealth (social ties in food-sharing networks and other types of assistance), and material wealth (land, livestock, and house and household goods).

The Gini coefficient, which summarizes inequality in a population as a single number between 0 (100% equal) and 1 (100% unequal) based on income, has been a popular tool in modern populations because of its simplicity and because it can be compared across countries around the world (e.g. by United Nations accessed 2021). However, income data are not available for prehistoric populations, and thus, different proxy-measures have been utilized to calculate Gini coefficients. These include grave goods, domestic artefacts, house floor area, and storage sizes (see Smith, Kohler and Feinman 2018 for an overview of studies).

Another measure for modern populations, the Human Development Index (HDI), combines income, life expectancy, and education in order to measure human development in a way that can be compared across countries. Oka et al. (2018), inspired by the HDI, proposed a Composite Archaeological Inequality (CAI) index to combine inequality measures based on different material sources and across historical and archaeological sample populations, also with the purpose of comparing populations of different economies.

Grave good wealth is particularly difficult to quantify as perceived object value may vary considerably between populations and periods and is unknown to us from prehistoric materials. Some studies attempt quantification by grave good plurality (Hedeager 1992; Mittnik et al. 2019; Nieszery, Breinl and Endlicher 1995; Szmyt 2002), called Total number of Object Types (TOT) in this study. However, this treats each object with equal value, no matter the material or count, which may skew grave wealth distributions (Nieszery, Breinl and Endlicher 1995: 205). Ethnographic (e.g. Dalton 1977; Olausson 1983b: 12-14) and archaeological studies (Grossmann 2021; Nieszery, Breinl and Endlicher 1995; Todorova 2002) do mention some overlapping grave good value parameters, such as scarcity, manufacturing hours, distance to raw materials, required manufacturing skill, and exaggerated shapes, which can be quantified to some extent. However, in quantification studies, the focus has usually been on one parameter (e.g. scarcity) or, when combined in point systems, transparency for each value point is lacking (see SI: section 2) for more detail on this). This makes cross-study comparison difficult. The present study attempts to combine multiple value and wealth parameters (including TOT) in a transparent and reproducible way, also introducing an additional case-specific 'prestige' value measure derived from the median of the TOT range for each object category.

The size of a grave pit may reflect status (e.g. Grossmann 2021), and this can be measured using volume, area or depth (the bottom of the grave in this study). However, both area and volume are likely affected by body size, and thus unrelated to status or wealth. Large grave goods (e.g. large pots) may also affect the grave pit area and volume while smaller items (e.g. metals) may have been more valuable. Grave depth should be less affected by body size (Bösel 2008: 51), and it is therefore used here as an additional measure of status.

Table 1: Wealth parameter measures and their units used in this study.

Wealth_parameter	**Measure_unit**
TOT	represented number of grave good categories
manufacturing time	person-hours
skill	percentage (0.0, 0.2, 0.4, 0.6) of person-hours
import value	travel hours (with 7 km/h) to raw material
scarcity	total number of graves/number of graves with X material
prestige	median of TOT range for each grave good category
estimated meat (from MNI of animal bones)	kg + separate scarcity and prestige bonus
grave depth	cm
house area size	m^2

2 Source Critical Considerations

Using graves as a direct and universal measure of social inequality through a processual theoretical lense on a population is not straightforward. While there may be correlations between, e.g. metal-bearing or polished stone-bearing graves and more protein or nutrition intake from high trophic food such as meat and dairy reflected in δ^{15}N and δ^{13}C stable isotopes (Budd et al. 2020; Masclans Latorre, Bickle and Hamon 2020), this cannot be expected to be a universal pattern for metal-bearing grave goods. Furthermore, δ^{13}C levels may be affected by local environments requiring a thorough baseline, and δ^{15}N levels may be affected by manuring of staple crops or an increased fish diet, and pastoral communities may have been generally more reliant on high trophic food sources such as meat and dairy (Knipper et al. 2020: 128). This could make high trophic diet less diagnostic of lived high status. These caveats should be kept in mind as well for the results on inequality of the present study.

Even when taking grave goods at face value, it can be difficult to know whether they reflect the wealth of the individual in life (material wealth) or wealth transmitted by next of kin at the burial, or in some cases perhaps even by the whole community in which case it may rather reflect social status and relational wealth. Thus material wealth and social status (and relational wealth) in a community can hardly be disentangled. However, use-wear studies of grave goods have shown that it may be possible to see if an object has been freshly manufactured (no or little use-wear), perhaps specifically as a grave good, or used or worn for a long time before the burial (Frînculeasa et al. 2020; Masclans Latorre, Bickle and Hamon 2020), either by the individual or those adding their used belongings in the grave. The former could indicate lived material wealth, and the latter could indicate transmitted affectionate value. However, the grave goods in this study have not been studied in such detail, and social status and material wealth are therefore not distinguished in this study.

Preservation of organic remains (apart from skeletal material) such as textiles may also have reflected important social symbology and status, and would have been very labourious to make, but are rarely preserved. The rapid decay of such organics potentially skews the results in favour of less fragile materials. Thus, if females expressed status or wealth more through textiles than males did, a male bias would appear in terms of gendered wealth and status. Ritual activities during the burial, probably conveying considerable meaning and status, are also difficult to reconstruct, except for, the sprinkling of red ochre (only a red ochre lump in one grave) or funeral feasting, possibly indicated by animal bones in the graves. The latter is included here as estimated usable meat of whole animals in kg from minimal number of individuals (MNI), including scarcity and prestige bonus (SI: section 5). Grave disturbance also adds uncertainty to the interpretation of burials (cf. Kolář 2012), more on this aspect below.

3 Background to the Case Study

With the rise of ancient genomics, it is now clear that there was a major and relatively abrupt male-biased population influx from the Pontic-Caspian steppe/forest-steppe to 3rd millennium Central and Northern Europe (Papac et al. 2021; Scorrano et al. 2021), perhaps fueled by intensified herding (Wilkin et al. 2021), although not on horseback (Librado et al. 2021). This new influx of people correlates extraordinarily well with the linguistic 'steppe-hypothesis' of Indo-European language dispersal (Anthony 2017; Anthony and Brown 2017; Anthony and Ringe 2015; Chang et al. 2015), including borrowing agricultural vocabulary from Neolithic farmers (Iversen and Kroonen 2017). Recent archaeogenomic studies have shown that Corded Ware (CWC) and Bell Beaker (BBC) societies of the 3rd millennium BCE tend to have been patrilocal, patrilinear, and practicing female exogamy (Mittnik et al. 2019; Papac et al. 2021; Sjögren et al. 2020), also supported by reconstructed Indo-European kinship vocabulary (Olsen 2019; Sjögren et al. 2020). A non-random decrease in Y-haplogroup diversity from early to late CWC in Bohemia, and elsewhere, during the early 3rd millennium BCE may also reflect competition between male lineages or 'an isolated mating network with strictly exclusive social norms' (Papac et al. 2021: 6; Zeng, Aw and Feldman 2018).

The CWC has been interpreted as relatively mobile with a mixed agriculture and herding and gathering economy (Lechterbeck et al. 2013), and more focused on the individual and the core family than the preceding agricultural societies in Europe (Harrison and Heyd 2007; Kristiansen et al. 2017: 343). CWC burial rituals are associated with burials under mounds in clear gender differentiation, reflected in body position (males lying on their right side, females on their left side) and in grave goods (males with battle-axes, females with ornaments) (Iversen 2015: 135, 166; Wiermann 2002). However, exceptions to this pattern occur (Furholt 2014), and males generally show more supra-regional patterns while females show more local patterns (Bourgeois and Kroon 2017; Olerud 2021).

Moravian CWC radiocarbon dates, while still relatively few in number, indicate a later occupation around 2600-2000 cal BCE than in other areas of Europe, thus overlapping with the Moravian BBC (2500-2000 cal BCE) and Proto-Unětice cultures (c. 2450-1900/1700 cal BCE) (Kolář 2018: 43-44). Due to the lack of large cemeteries and available radiocarbon dates, the data in this study is spread over several hundred years and several different sites, and therefore do not represent one coherent community, which limits the power of conclusions made here.

Moravian CWC residential areas are absent (and generally rare across the CWC) (Kolář 2018: 142), and thus the analysis for Moravia focuses on graves. For comparison, a house area Gini index was instead produced combining CWC houses from different regions (see below). Unlike northwestern CWC, Moravian (and other Central European) CWC graves have metals (at least 13%, Kolář 2018: table 13). However, less than 0.1% of CWC graves are interpreted as metallurgist graves (by metal-working tools), while Bell Beaker metallurgist graves are less than 1% (Peška 2016: 2:4). The Morava river likely kept the CWC community connected with metal producers around the Upper Danube, the Carpathian Basin, the Balkans, and possibly the steppe (Kolář 2018: 189). Moravian CWC metals have not been provenanced by lead isotope studies, but may have come from the Špania Dolina copper mine in Central Slovakia (about 200 km) and perhaps the Northeastern Alpine foothills (Kolář 2018: 170). Gold may have come from the Aries river in the Apuseni Mountains in Romania (about 700 km away, only one gold hair-decoration in this study, grave 155.1.4) where roughly contemporary alluvial gold sources have been identified (Cristea-Stan and Constantinescu 2016). Many burial mounds in Moravia were poorly excavated and documented before World War II or destroyed by modern agriculture (Kolář 2018: 58, 79, 90) which makes it difficult to use mound size (or even the presence or absence of mounds) as a wealth-proxy.

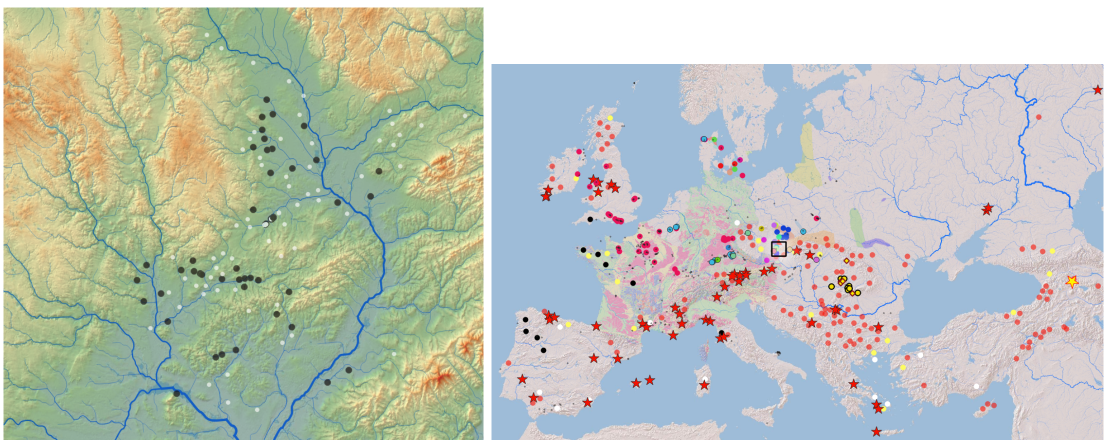

Figure 1: Left: Map of CWC sites in the study region from Sebela 1999 and Kolar et al. 2011. Sites with skeletal remains (black) and sites without skeletal remains, not included in the analysis (white). Right: raw material source data (see larger map and literature in the SI) with the study area marked (black square). Collected and mapped in QGIS by the author.

4 Materials and Methods

All analyses were done in R version 4.1.2 (2021-11-01) (R Core Team 2021) via RStudio (RStudio Team 2020), with the tidyverse package (Wickham et al. 2019) for data manipulation. Graphics were produced using the ggplot2 package (Wickham 2016), the Lorenz curve ggplot add-on (Chen and Cortina 2020), PCA with FactoMineR Lê, Josse and Husson (2008) for which missing grave depth values using imputed with the missMDA package (Josse and Husson 2016), see colophon in Appendix for a list of all packages used. Grave and grave good data for 82 Moravian individuals in 81 graves from 46 sites were collected from the catalogues by Kolář (2011) and Šebela and Rakovský (1999). Gini indices were calculated using the DescTools package (Andri et mult. al. 2021), with confidence interval settings set to accelerated bias-corrected ('bca'), 4000 bootstrap replicates, and 80% confidence level following Oka et al. (2018).

Overall grave good value was calculated using five different value parameters: manufacturing time (in person-hours (PH), see SI: section 4 for details), prestige/symbolic value (median of TOT range for each grave good category), scarcity (total number of graves / graves with that material as in Grossmann (2021), using the overall Moravian CWC numbers from Kolar (2018: table 13), SI: 3.3), travel hours for imported objects (assuming an average speed of 7 km/h, SI: 3.2), and a separate measure of skill bonus as percentage of PH in four different levels (low=0.0, medium=0.4, high=2.0, very high=5.0, and a hypothetical expert=10.0, for exceptional artefacts requiring >10 years of focused training to make), SI: 3.1. Estimated consumption of animal meat at the burial, assumed here to reflect feasting (Hayden 2009), was calculated from the MNI of animal bones (assuming bones represent whole animals slaughtered), including scarcity bonus of animal bones and prestige bonus (SI: section 5). Since these may all reflect some aspect of grave good value, they were normalized to give them equal weight, and the sum of all six (incl. animal meat) for each grave was used as a measure of *overall grave good value.* Three different Gini coefficients were computed on the grave data which were used as basis for the CAI: combined grave good value, TOT, and grave depth (unimputed), see figure 6.

Secondary manipulations of the human remains, e.g. later grave disturbance, are rarely documented for excavations of Moravian CWC graves before the 1970s, and primarily after 1995 (Kolář 2018: 74-78). The majority of the data are from Sebela which only has excavations from before 1991 (Šebela and Rakovský 1999: 15), and only 12 of these have complete documentation (denoted “VN 1” and “VN 2” in Šebela and Rakovský 1999: 16). Therefore, undocumented secondary manipulations should be expected for some of this material. Only single graves with preserved skeletal materials were used (except for one double grave, Iv4_807A/B, where the grave goods were listed separately, Kolář 2011), such that grave goods could be connected to the individual with reasonable likelihood (see figure 1).

Objects in the infill occurred in 8 graves (155.1.3 (barrow preserved), 197.1.1, 347.1.5, 97.1.1, Hos_802, Iv4_800, Iv4_807, and Iv4_810, in most cases potsherds and pebbles, but also a few copper items and bone tools). Their role in the burial situation is therefore not clear, adding some uncertainty to the data. However, these cases comprise less than 10% of the graves, and would hardly skew the data or the analyses significantly.

The value of time in prehistory is uncertain, but food production in the Neolithic may have occupied at least 5 hours per day throughout the year, and available artefact manufacturing time may have been somewhat limited by daylight hours (Kerig 2007), except perhaps for very simple repetitive work such as making numerous shell beads (SI: 4.6). Thus, manufacturing time may have had some limited value. Even so, making accurate and general estimates of manufacturing time of prehistoric artefacts is extremely difficult because a myriad of factors affect the end result and the time used, not least the speed and methods of the person doing the work and how it is documented (for a more detailed discussion on this ‘it depends’-dilemma, see Petty (2019)). Therefore, any time estimates used in this study are crude approximations at best and would ideally have been done through several years of data collection and controlled experiments which would be entirely beyond the scope of this study, (see SI: section 1). However, it is hoped that the transparency of this framework takes the initial steps towards continuous collection and improvement of such data. Since manufacturing time accounts for just 1/5 (2/5 incl. skill) of the overall grave good value, and 1/8 (2/8 incl. skill) of all grave wealth measures, inaccuracies should not affect the overall results significantly.

In order to set up a relatively flexible computation system for grave good manufacturing time (using PH), the data were, partly based on the table structure in Kolář (2011), divided into the main materials: Groundstone (SI: 4.3), flint (SI: 4.2, subdivided into flint axes and other flint), Osseous artefacts (SI: 4.5), shell ornaments (SI: 4.6), metals (SI 4.4), ceramics (SI: 4.1, subdivided into pots and other), and animal bones (SI: 5). This was done for both the archaeological data and for the reference data from experimental, ethnographic and prehistoric crafts people sources. The time estimates from the reference data thus form the basis of the time estimates for the archaeological data based on a number of parameters within the *chaîne operatoire* of each artefact. As an example for pottery vessels (based on an interview with the historical potter Inger Heebøl at Lejre Land of Legends), size is a major (and easily quantifiable) criterion of shaping time and skill. The largest single measure of the pot’s dimension gave the best correlation with time, even for different potters (SI: 4.1.1), and requires the least from the archaeological data quality. Apart from pot size, percentage surface cover of impressed decoration, plastic decoration, polish, smoothing/beating, type and amount of temper, slip/paint (where relevant), and firing were also used as separate factors on the time estimate, usually together with size. However, a minimum time for the smallest and most simple pots was indicated by the reference data, and applied to the archaeological data. See SI: 4.1 for full details.

Flint and stone axes/adzes and daggers were divided into extraction, blank-knapping, preform-knapping, grinding, sharpening, and wooden handle (presuming these were hafted). Skill bonus based on knapping and grinding time was added for axes/adzes longer than 30 cm (not relevant for Moravian CWC) and thickness below 2 cm, and with extraordinary polish or shine inspired by Olausson (1983b): 12-13 (see SI: 4.2).

Time for groundstone tools was initially calculated based on Mohs hardness and fracture toughness, primarily from Pétrequin (2012) on Neolithic Alpine axes. However, when later adding experimental data for battle axes and thin-butted groundstone axes from Olausson (1983a), there was no correlation with these factors at all (many different combinations were tested), and Olausson (*ibid.*) demonstrates that stone tools can be made much faster than usually estimated. Therefore, a preliminary solution was to use the respective medians of the times given for Alpine axes vs. other groundstone axes (such as battle axes), but including hardness and toughness as lesser factors (SI: 4.3). This underlines that the experimental study design and approaches (and perhaps documentation method) can be critical caveats for reported manufacturing times. More systematic experimental data, beyond the scope of this study, may correlate better with hardness and toughness.

CWC metals were usually simple copper ornaments and tools shaped from wire or sheet (Kolář 2018), and in the 3rd millennium most copper ornaments generally seem to have been shaped by cold-forging (e.g. hammering and rolling) with frequent annealing in-between (Fregni 2014: 130). The whole *chaîne operatoire* was divided, following Brinkmann (2019), into mining, ore beneficiation, smelting, forging from raw nugget state (but mould manufacture, melting, and casting for cast objects), production/maintenance of metallurgical tools, and post-processing such as grinding, polishing, and, for cast metals, also removing excess metal ('jet') (SI: 4.4).

The system thus takes the detailed description of the archaeological artefacts for each material into account using separate material-specific data tables and scripts which flow into a final script adding all of the PH calculations into one final table (see SI: 6, and total result in Appendix table 5). A simplified graph of the whole manufacturing structure is given in figure 2.

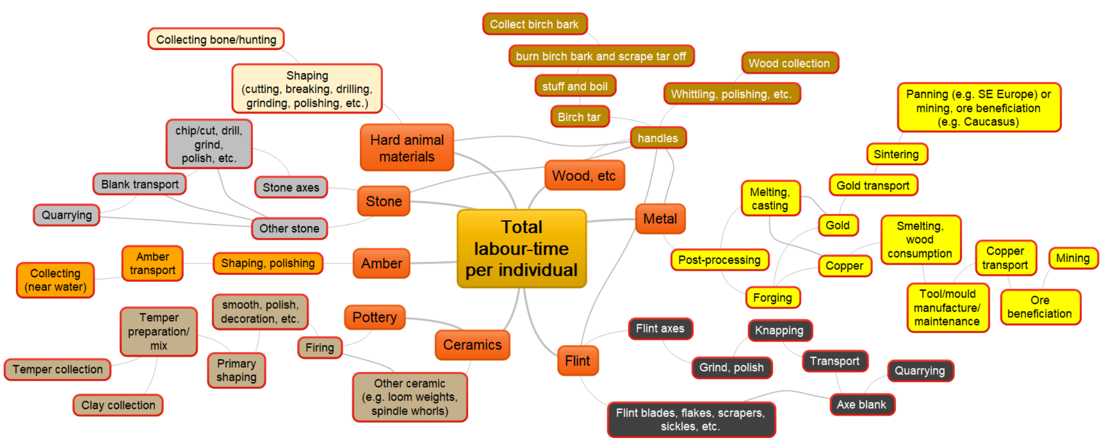

Figure 2: Simplified graph of automated PH system. Each material around the center represents one or several R scripts calculating PH depending on their respective chaînes operatoires. Drawn in MindMaple by the author.

5 Results

All grave goods for the 82 individuals were divided into material-specific tables. On this basis, different grave good value aspects: manufacturing time and skill, were calculated based on the reference data from experimental, ethnographic and craft people sources. The calculated results for each material were automatically merged into one final table summarizing all 82 individuals, see table 5. Distance to raw material and frequency of each material within the study area were added to the material-specific tables and used to calculate import travel hours and scarcity.

Separately, the TOT measure (given as presence/absence for each grave good category, in this case spanning 0-10 represented categories from 'poorest' to 'richest', was calculated and used as basis for a separate Gini index, and for the prestige measure. Figure 3 shows a boxplot of the different TOT ranges for each grave good category including the median. This indicates that some categories are exclusive to the upper half of the spectrum (score in parentheses): gold hair decoration (10), shell (7.5) and tooth beads (6.5), stone axes (6), copper awls/needles (6.5), and copper knives/razors (5). Ceramic pots span the whole TOT spectrum but cluster in the lower half (3 and 4, probably reflecting the general population's TOT distribution). Battle-axes surprisingly cluster below the middle of the spectrum (4) and the single spindle whorl is positioned at the lower end (3). While some shell and tooth beads were locally available, the fact that they are exclusive to the upper TOT spectrum, is also supported by a wider study of CWC ornaments (Kyselý, Dobeš and Svoboda 2019). Thus, the 'prestige' measure gives a separate aspect of grave good value from scarcity distinguishing shell and tooth beads from spindle whorls although they are both rare in these graves.

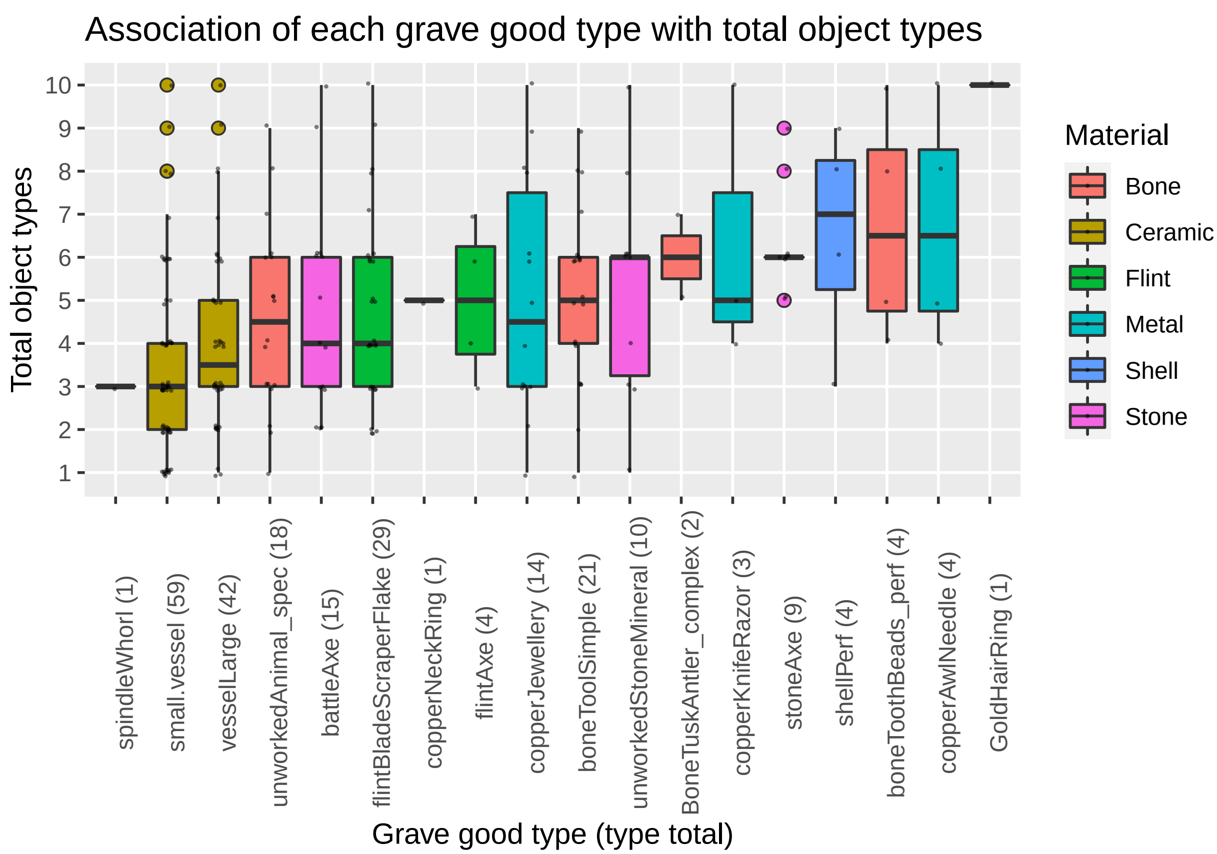

Figure 3: Association of each grave good type with TOT.

The medians mentioned above were applied as 'prestige' values instead of the raw grave good counts, then summed for each grave, and added to the other grave good value parameters in one final grave good table (table 5). All grave good value parameters (manufacturing time, skill, import travel hours, scarcity, prestige, and meat consumption) were normalized, and the sum of these values was calculated for each grave. A Gini index was then calculated for the normalized sum. A separate Gini index was also calculated from grave depths as reported in the catalogues (excluding graves that were too damaged to determine this).

Some grave good value parameters are more correlated than others. Principal components analysis of the eight grave wealth measures as active variables (and materials as passive variables) was applied to the graves (excluding the extreme outlier graves 177.1.1 and 155.1.4), with variables coloured by their percentage contribution to PC1 and PC2 (figure 4). The individuals form three groups (with 95% confidence ellipses): Group 1 is especially associated with grave good artefacts of higher value (along PC1), Group 2 is not associated with any value measures, and Group 3 is primarily associated with meat (along PC2). All measures have significant positive correlation along PC1 (P=7.493e-03 to 9.816e-35, accounting for ~59% of the variation), but PH, prestige, TOT, skill, scarcity, and travel (in that order, P=9.816e-35 to 3.744e-16) have higher significance than grave depth (P=2.407e-08) and meat (P=7.493e-03). Conversely on PC2 (accounting for ~14% of the variation), only meat has significant *positive* correlation (P=8.087e-27) along with flint (P=1.241e-03), while grave depth (P=1.199e-03), metal (P=8.551e-03), and travel (weaker P=1.518e-02) have significant *negative* correlation. It may seem redundant to include so many correlating parameters, but doing so ensures that as many aspects of value as possible are taken into account, e.g. labourious objects need not require high skill to make, and objects scarce in graves need not be prestigious. Furthermore, comparing this with material groups fosters the emergence of interesting patterns. Thus, (estimated) meat expenditure and flint artefacts (excluding imported artefacts such as metals) in funerals may reflect a more local expression of wealth or status (including 'popularity'), than artefact value measures and grave depth.

The Gini indices are based on the data summarized in figures 4 and 5 and table 2.

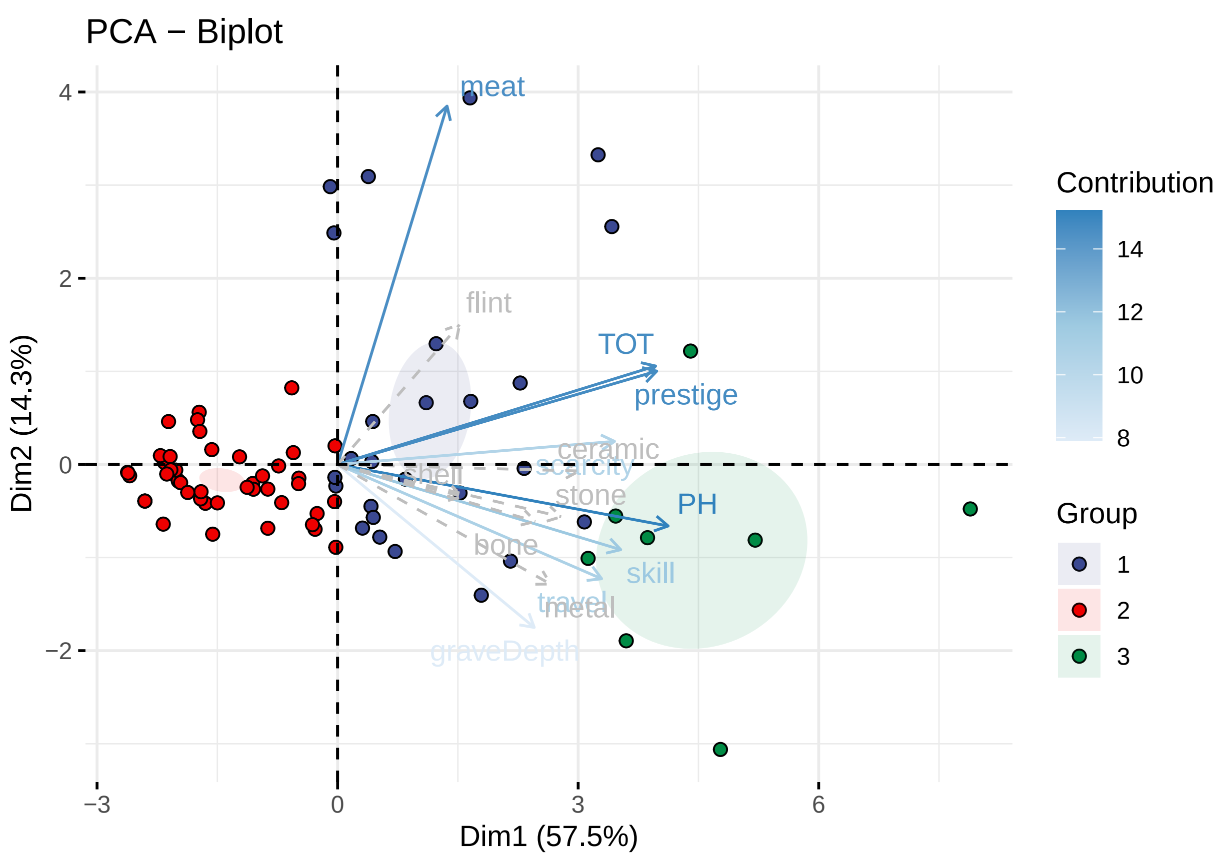

Figure 4: A biplot from a PCA of manufacturing time, skill, scarcity, travel-hours, prestige, and estimated meat consumption, as well as materials, and individuals forming three groups.

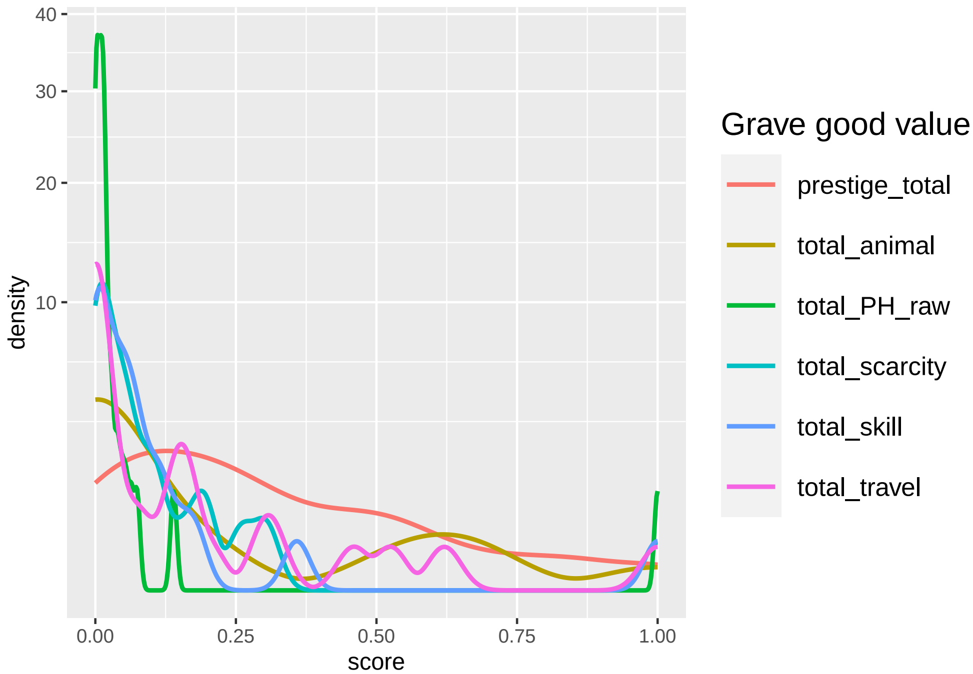

Figure 5: Square root of densities of manufacturing time, skill, scarcity, travel-hours, prestige, and estimated meat consumption

Table 2: Summaries of the data foundation of the Gini coefficients.

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Total Object Types	0.0	1.00	3.00	2.88	4.00	10.00
person-hours	0.0	4.67	18.39	46.11	28.46	1713.82
scarcity	0.0	1.10	3.76	10.98	11.39	164.35
skill bonus	0.0	1.73	15.93	28.54	32.13	508.73
travel hours	0.0	0.00	0.00	13.53	14.29	186.43
prestige	0.0	3.50	8.75	11.68	16.25	48.00
animal meat	0.0	0.00	0.00	31.23	0.00	397.32
Grave good normalized sum (0-6)	0.0	0.12	0.31	0.54	0.76	4.06
grave depth	2.0	27.50	55.00	61.44	78.25	250.00
CWC house sizes	24.3	62.00	104.50	102.61	131.02	227.54

Combining all aspects of grave wealth gives three different measures: TOT, grave depth, and combined grave good value (including meat consumption).

The Gini coefficients and Lorenz curves for the 82 Moravian CWC individuals in this dataset are given in table 3 and figure 6 along with scarcity for comparison with Grossmann (2021). The Lorenz curve plots the percentage distribution of the sample population on the x-axis and the accumulated percentage of the given wealth measure on the y-axis ordered from the poorest to the richest graves. Grossmann (2021: 87) gets a grave good scarcity Gini index of 0.69 for Lauda-Königshofen (Southern Central German CWC 2600-2500 BCE). A scarcity Gini of 0.672 for Moravian CWC is quite close to this, although both values are very high compared to CWC house size Gini indices (see below).

Table 3: Gini coefficients based on TOT, PH, and scarcity.

	gini	lwr.ci	upr.ci
Gini_TOT	0.405	0.373	0.448
Gini_graveDepth	0.393	0.364	0.428
Gini_GG_normed	0.564	0.525	0.623

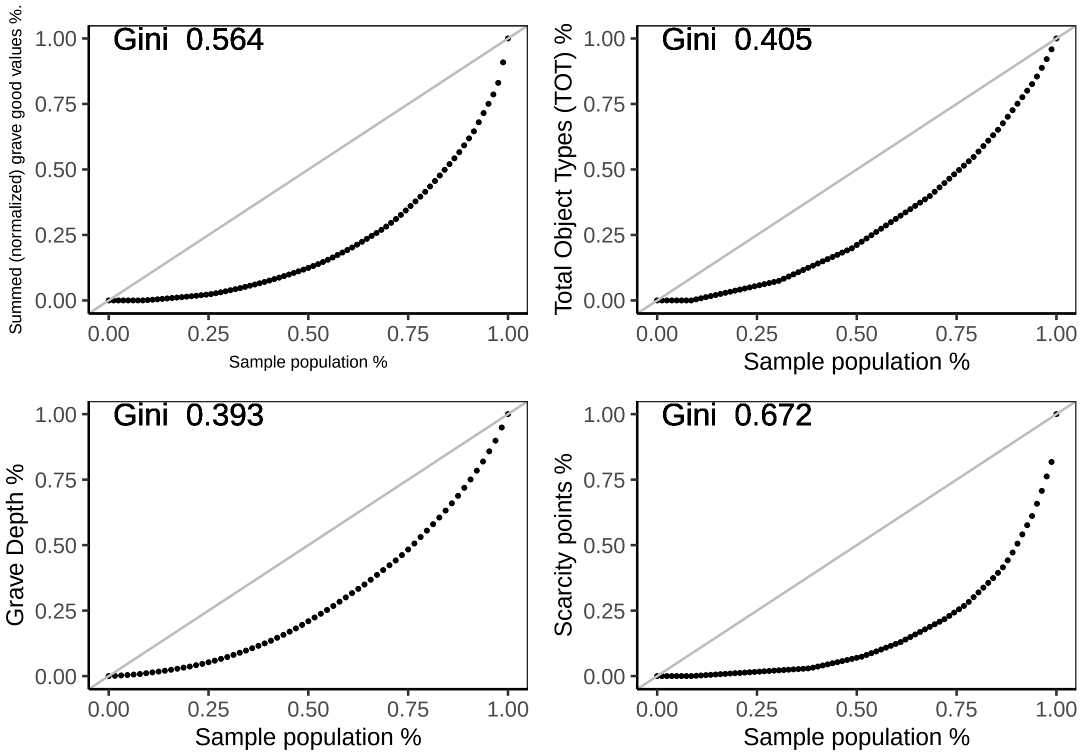

Figure 6: Lorenz curves for grave depth, Total Object Types, manufacture PH, and scarcity sensu Grossmann 2021

To get an approximate baseline, Gini indices from house area data over different periods and regions of Central and Northern Europe were calculated using data from various contributions in Risch et al. (2019) (CWC), Globular Amphora Culture (GAC), Unětice, and other Middle, Late and Final Neolithic cultures (Scand MN and FN_CA)), Balfanz, Fröhlich and Schunke (2015) and Conrad, Schmalfuß and Richter (2018) (BBC), Schmalfuß et al. (2018) (Lausitz culture), García Diaz (2017), Sørensen (2015), and Sparrevohn, Kastholm and Nielsen (2019) (Scandinavian Early Neolithic (EN), incl. CWC).

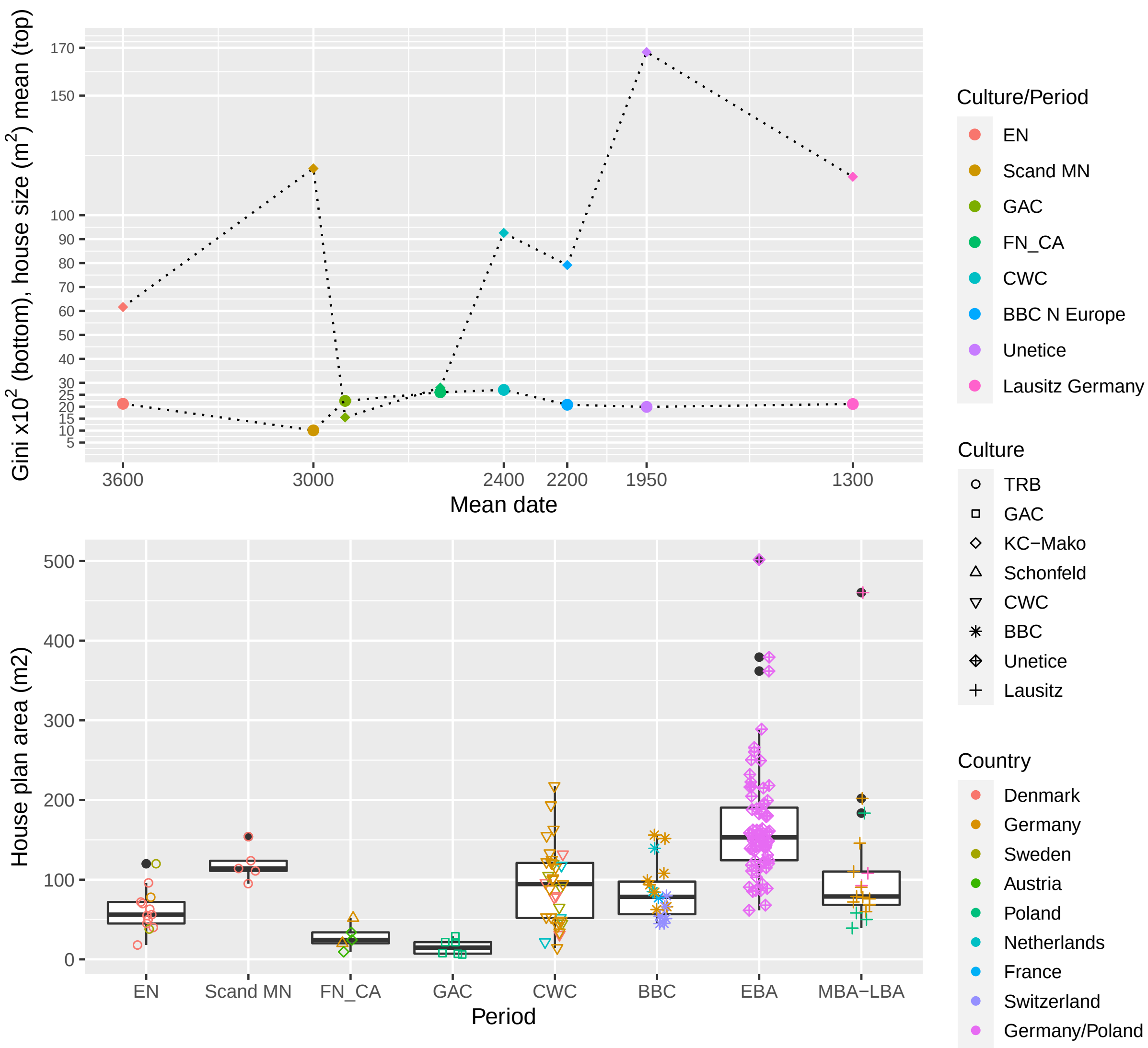

Figure 7: Gini indices and mean sizes of Neolithic to Bronze Age houses

Table 4: House area Gini indices (adjusted) with CI, original house area Gini indices, and house area mean (original) for each culture/period.

name	mean_date	gini	lwr.ci	upr.ci	gini_original	mean	gini_perc
EN	3600	0.212	0.178	0.293	0.246	61.62462	21.2
Scand MN	3000	0.101	0.072	0.134	0.109	119.55000	10.1
GAC	2900	0.224	0.191	0.253	0.369	15.52667	22.4
FN_CA	2600	0.260	0.216	0.332	0.352	27.95800	26.0
CWC	2400	0.270	0.239	0.317	0.299	92.61455	27.0
BBC N Europe	2200	0.208	0.182	0.243	0.232	79.18700	20.8
Unetice	1950	0.199	0.174	0.235	0.211	168.18014	19.9
Lausitz Germany	1300	0.211	0.166	0.270	0.233	116.08706	21.1

The house area Gini indices (x10^2, lower line) and mean of areas over time (upper line) are given in figure

7 and in table 4. The Gini index is designed for income ranges which are generally much higher than the smallest houses (or rather huts) in this study. Therefore, Gini indices became very high for GAC (36.9) and FN_CA (35.2) because they have very low and small ranges. This only affected higher ranges slightly (e.g. CWC from 29.9 to 27.0). To diminish the effect of this artefact, the lower bar was increased by adding 10 m^2 to all house sizes before computing the Gini (house sizes given in this paper are still the original numbers). The adjusted Gini indices now all give a value ranging from 10's to early 20's, the GAC and FN_CA decreasing the most. CWC has 0.27, higher than any other group.

The grave CAI index, for the TOT Gini, grave depth Gini, and combined grave good Gini is 0.448. Fochesato et al. (2021; 2019) found that grave Ginis tend to be higher per individual than per household (i.e. hypothetical couples) across case studies, and that individual Ginis in graves should thus be corrected by a ratio of 0.91-0.92. On that background, the mean (0.915) ratio is applied in this study giving a household-adjusted grave CAI of 0.408. The difference between house and grave CAI is still quite high at 33.8%. If we accept that the 'true Gini' approximation lies somewhere between the Gini for house sizes and the CAI from graves, we may again apply the CAI to these two values which gives a combined house and grave CAI of 0.302. Alternatively, we could use the arithmetic mean of the two which is 0.339, in both cases placing the Moravian CWC inequality measure generally in the low 30's.

6 Discussion

Fochesato et al. (2019: 13-15 and table S5), based on four cases with both graves and houses (Late Neolithic Gomolava, Western Balkans, Early Dynastic Kafajah, and Old and Neo Babylonian Ur, Mesopotamia), find a general difference between grave good and house size Ginis of 0.244-0.343 (or an average of 28.1%) for which they downgrade the grave Gini to match the house Gini. However, all four cases are agricultural (some even state) societies, and there could be different variations depending on the social norms and economy of a given society. Furthermore, making house sizes the gold standard of the expected Gini level, may be misleading, due to houses/huts without wooden posts (tents, small huts, etc.) being archaeologically invisible or difficult to measure.

A similar argument can be made for missing parts of the population in grave data which could have been at the lower tier of society or slaves. Fochesato et al. (2019: table S4) reconstruct the missing population in Southern Mesopotamia to be 34% and in Roman (rural?) Italy to be 9%. Both of these are state societies, and presumably much more dependent on institutionalized slave labour than expected for Neolithic societies. If we accept the association of Indo-European language with 'steppe' ancestry dispersal, we may also get an indication of how institutionalized slavery was in steppe-derived populations such as the CWC by looking at reconstructed 'Core-Indo-European' (Proto-Indo-European excluding the Anatolian branch) vocabulary of slavery. While such vocabulary is widespread in the daughter languages, and while military, conquering activities, and looting vocabulary is easier to reconstruct, it seems difficult to reconstruct a word specifically meaning 'slave' or 'servant' (Campanile 1998: 16-17; Nørtoft 2017: 84-89). Therefore, we might not expect a large proportion of missing 'unfree' in pre-Bronze Age steppe-derived cultures, probably less than 9% (Roman Italy), and the impact of slaves on the Gini index may be limited. However, it is still uncertain if only the upper tier of society were buried in a way that leaves traces today, potentially leaving a large 'missing' population, e.g. due to taboo, 'sky' burials, shallow graves destroyed by the plough or children's bones disintegrating faster (Kolář 2018: 68, 101). The author instead follows Fochesato et al. (2021: 3) in not correcting for a missing population, because the data has graves without grave goods.

This study suggests using the CAI for houses and graves together instead of downgrading grave Ginis by a fixed 28.1%. This acknowledges extreme grave wealth inequalities while still downplaying generally exaggerated grave wealth Ginis towards house Ginis. In future cases with only a Gini for houses, or only a CAI for graves, we could perhaps extrapolate from this example that the grave CAI is overestimated from the *combined house+grave CAI* by 26, and house Ginis are underestimated by 10.6 Gini points. We could thus adjust the respective Gini indices accordingly for comparison between case studies. However, more case studies should be done to determine the reliability of this difference. The relatively small adjustments to the Gini or CAI may seem insignificant, but the combined measure is more data-driven, transparent, and includes several aspects that seem to define wealth in ethnographic studies (e.g. Bösel (2008), Dalton (1977); Olausson (1983b)), thus more applicable and comparable between different cases.

The different measures combined with material groups in the PCA also show new patterns such as graves with local traditions of animal sacrifice distinguished from graves with imported high value grave goods such as metals. This could perhaps reveal 'commoner'-looking individuals with high status who had less access to long distance metal networks, and may have used the funeral as an opportunity to gain importance in society by organizing a feast.

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8 Competing Interests

The author knows of no competing interests that could have affected this study.

9 Ethics and Consent

The craft specialists mentioned in this study were used as consultants on estimated time and techniques for manufacturing prehistoric objects, and informed beforehand that their knowledge would be used in this study. For one plot (in SI: fig. 4.3) comparing the manufacturing time recorded by different potters relative to pot size, the potters have been anonymized. Any other data used was publicly available in literature or online videos.

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11 Appendix

Table 5: calculated manufacturing time, prestige points, scarcity points, import travel points, skill points, and animal meat for feasts (estimated kg), and their respective means, and normalized sum (range of 0-6) per grave.

Grave_ID	SiteName	total_PH_raw	prestige_total	total_scarcity	total_travel	total_skill	total_animal
100.3.1. Gr. 1	Hradisko	2.9375451	3.0	1.098404	0.0000000	1.0560000	0.00000
104.1.1.1 Grave 1 (VN 1)	Nivky	11.4866579	10.5	3.762920	0.0000000	10.5628000	0.00000
121.1.1. Gr. 1	Kloboucky	2.6835761	3.0	1.098404	0.0000000	1.5870000	0.00000
132.1.7.2 Barrow 2 (VN 1)	Kostelec u Holešova	26.4346466	11.5	49.651809	6.8571429	30.8887994	0.00000
14.1.1. Gr. 1	Blucina	23.9919286	23.0	11.386260	7.8571429	2.0695000	59.20465
143.1.3. Gr. 3	Krumvír	23.7404269	3.5	1.098404	0.0000000	42.7800000	0.00000
143.1.4. Gr. 4	Krumvír	0.0000000	0.0	0.000000	0.0000000	0.0000000	0.00000
143.1.7. Gr. 7	Krumvír	75.5643003	18.0	16.394701	57.1428571	57.1175380	0.00000
143.1.8. Gr. 8	Krumvír	0.0000000	0.0	0.000000	0.0000000	0.0000000	0.00000
148.2.1. Gr. 1	Kyjov-Netcice	32.6746369	25.0	6.410356	1.4285714	22.1426988	64.46465
155.1.1. Br. 3	Letonice	33.8304040	18.0	8.738824	0.0000000	39.7180000	0.00000
155.1.2 Barrow 4 (VN 1)	Letonice	67.4168816	23.0	8.721744	1.4285714	89.9602122	0.00000
155.1.3. Br. 5	Letonice*	25.4193404	12.5	11.386260	0.7142857	18.8962374	14.10465
155.1.4 Barrow 6 (VN 1)	Letonice	238.7162360	48.0	164.349223	186.4285714	182.3080140	0.00000
173.1.4. Gr. 4	Lutín	24.2554960	11.0	8.746552	28.5714286	22.0556680	0.00000
177.1.1 Grave 1 (VN 1)	Marefy	1713.8168755	38.0	44.307320	85.7142857	508.7316869	215.70465
177.4.5. Gr. 5	Marefy	24.6017188	10.5	3.762920	0.0000000	34.0808000	0.00000
197.1.1	Morkuvky*	23.8873415	20.5	1.098404	0.0000000	31.4520000	0.00000
198.1.1. Gr. 1	Mostkovice	30.0583667	11.0	8.746552	28.5714286	26.0950060	0.00000
199.1.2. Gr. 2	Mouchnice	34.6897417	6.5	1.098404	0.0000000	50.2000000	0.00000
20.1.1. Gr. 1	Boleradice	14.6420813	16.5	26.707365	14.2857143	2.1861333	397.32465
207.1.1. Gr. 1	Nechvalín	11.9533223	3.0	1.098404	0.0000000	5.5939333	0.00000
207.1.3. Gr. 11	Nechvalín	22.9516818	11.0	1.098404	0.0000000	37.3770000	260.80465
207.1.6. Gr. 18	Nechvalín	12.9672313	7.0	3.762920	0.0000000	13.6943333	0.00000
232.1.1 Grave 5 (VN 1)	Pavlov	85.0965755	6.5	41.978853	115.7142857	72.6705558	0.00000
232.1.2. Gr. 14	Pavlov	28.9164292	31.0	31.683268	14.2857143	20.6172000	226.22465
24.2.1. Gr. 1	Brno	3.5614859	3.0	1.098404	0.0000000	1.7350000	0.00000
240.1.1. Br. 1	Podolí	17.4643104	12.5	8.721744	0.7142857	26.5834230	0.00000
246.1.1. Gr. 1	Prostejov	10.1824641	3.0	1.098404	0.0000000	5.3880000	0.00000
246.3.1. Gr. 1	Prostejov	18.3568064	6.5	1.098404	0.0000000	15.7120000	0.00000

Table 5: calculated manufacturing time, prestige points, scarcity points, import travel points, skill points, and animal meat for feasts (estimated kg), and their respective means, and normalized sum (range of 0-6) per grave. *(continued)*

Grave_ID	SiteName	total_PH_raw	prestige_total	total_scarcity	total_travel	total_skill	total_animal
25.4.2 Grave 1	Brno-Chrlice	2.8179082	3.5	1.098404	0.0000000	1.1093333	0.00000
257.1.1. Gr. 1	Pustimer	8.0425061	3.5	1.098404	0.0000000	10.4900000	0.00000
271.1.1. Gr. 1: Skel. 1	Sivice	29.3587965	14.5	6.410356	0.7142857	39.6491940	0.00000
273.1.1. Gr. 1	Slatinky	26.3170095	11.0	6.410356	0.7142857	33.5484748	0.00000
277.1.1. Gr. 1	Slavkov u Brna	26.2845006	15.0	3.762920	0.0000000	27.1078000	258.55865
281.1.1. Gr. 1	Smrzice	21.7578654	16.5	16.386972	28.5714286	10.8202580	0.00000
291.1.1. Gr. 1	Stráznice	20.6793605	7.0	3.745840	0.7142857	23.8743177	0.00000
294.1.1 Grave 5 (VN 1)	Sudomerice	4.4794948	3.0	1.098404	0.0000000	1.8263333	0.00000
30.1.1 Grave 9	Brno-Starý Lískovec	0.0000000	4.5	0.000000	0.0000000	0.0000000	35.14465
30.1.2 Grave 36 (VN 1)	Brno-Starý Lískovec	63.4021256	25.5	11.386260	29.2857143	86.0775235	0.00000
30.1.3 Grave 42 VN 1	Brno-Starý Lískovec	1.7454067	7.5	1.098404	0.0000000	0.6893333	24.62465
30.1.4 Grave 70 (VN I)	Brno-Starý Lískovec	2.7631375	7.5	1.098404	0.0000000	1.0926667	14.10465
312.1.1 Grave 1 (VN 1)	Tešetice	50.9057541	21.5	31.666188	22.1428571	22.9554000	0.00000
314.1.2. Gr. 2	Tovacov	24.6039562	7.5	8.746552	28.5714286	12.8059580	0.00000
321.3.1. Gr. 3	Tvarozná	12.4811575	8.5	6.074308	0.0000000	14.4900000	0.00000
321.3.2. Gr. 4	Tvarozná	0.0000000	0.0	0.000000	0.0000000	0.0000000	0.00000
347.1.1 Grave 1	Vícemilice	17.0818495	10.5	3.762920	0.0000000	18.5193333	0.00000
347.1.3. Gr. 3	Vícemilice	6.1599576	11.5	6.410356	0.7142857	1.7265000	0.00000
347.1.5 Grave 5 (VN 3b)	Vícemilice*	10.3333333	9.0	24.042849	14.2857143	0.4853333	0.00000
35.1.1 Grave 1 (VN 3a)	Bucovice	5.2606197	3.0	1.098404	0.0000000	2.7586667	0.00000
35.1.2 Grave 2 (VN 3a)	Bucovice	19.9993514	6.5	1.098404	0.0000000	30.3750000	0.00000
355.1.2. Gr. 2	Vresovice	47.2395961	26.0	11.386260	1.4285714	55.8230463	59.20465
368.1.1 Grave 1	Zelešice	47.6154203	27.5	30.560056	57.8571429	31.5825186	0.00000
56.1.1. Gr. 1	Celechovice na Hané	22.0401269	7.5	3.745840	0.7142857	39.3094748	0.00000
58.1.1. Gr. 1	Detkovice	19.9242759	26.0	16.386972	28.5714286	10.3389080	59.20465
72.1.1. Gr. 1	Drahlov	4.1096063	5.0	6.074308	0.0000000	1.2273333	0.00000
72.1.2 Grave 2 (VN 2)	Drahlov	21.4047878	8.0	6.410356	0.7142857	28.5003038	0.00000
93.1.1. Gr.2	Holubice IV	0.9273504	3.0	1.098404	0.0000000	0.3646667	0.00000
93.1.2. Gr. 26	Holubice IV	14.5863451	12.5	6.074308	0.0000000	7.0840000	59.20465
93.1.3. Gr. 36	Holubice IV	0.9323032	0.0	1.098404	0.0000000	0.3646667	0.00000

Table 5: calculated manufacturing time, prestige points, scarcity points, import travel points, skill points, and animal meat for feasts (estimated kg), and their respective means, and normalized sum (range of 0-6) per grave. *(continued)*

Grave_ID	SiteName	total_PH_raw	prestige_total	total_scarcity	total_travel	total_skill	total_animal
93.2.1. Gr. 1	Holubice VII	21.5902603	7.5	3.745840	0.7142857	25.9520000	0.00000
93.2.2. Gr. 2	Holubice VII	10.3828651	6.5	1.098404	0.0000000	5.0493333	0.00000
93.2.3. Gr. 3	Holubice VII	0.0000000	0.0	0.000000	0.0000000	0.0000000	0.00000
93.2.4. Gr. 4	Holubice VII	0.0000000	0.0	0.000000	0.0000000	0.0000000	0.00000
97.1.1 Grave 1 (VN 1)	Hoštice Farm*	95.3758471	33.5	19.034408	37.8571429	59.0011500	0.00000
Hos_801	Hostice 4	27.0978713	11.0	8.746552	28.5714286	24.7350420	0.00000
Hos_802	Hostice 4	39.9335368	23.5	49.651809	6.8571429	32.3152777	256.45465
Hos_838	Hostice 4	109.9286806	20.5	16.394701	57.1428571	59.1820813	226.22465
Hos_839	Hostice 4	16.0033157	11.0	1.098404	0.0000000	17.9370000	260.80465
Iv3_2_801	Ivanovice na Hane 3_2	18.4324584	15.5	8.738824	0.0000000	18.4131333	0.00000
Iv3_2_803	Ivanovice na Hane 3_2	13.7488790	7.0	3.762920	0.0000000	16.1444667	0.00000
Iv3_2_804	Ivanovice na Hane 3_2	1.0034493	3.0	1.098404	0.0000000	0.3980000	0.00000
Iv3_2_805	Ivanovice na Hane 3_2	13.6495438	4.5	8.746552	28.5714286	8.1089820	0.00000
Iv3_2_806	Ivanovice na Hane 3_2	3.3075652	7.0	3.762920	0.0000000	0.9533333	0.00000
Iv3_2_809	Ivanovice na Hane 3_2	14.8725244	14.5	13.722456	28.5714286	8.3740480	0.00000
Iv3_2_811	Ivanovice na Hane 3_2	6.8930330	3.0	1.098404	0.0000000	3.6470000	0.00000
Iv3_2_825	Ivanovice na Hane 3_2	34.1454794	14.5	18.004300	28.5714286	55.2744960	0.00000
Iv4_800	Ivanovice na Hane 4	49.1075287	21.0	16.386972	28.5714286	41.8279080	0.00000
Iv4_803	Ivanovice na Hane 4	0.0000000	0.0	0.000000	0.0000000	0.0000000	0.00000
Iv4_807A	Ivanovice na Hane 4	2.0288640	3.0	1.098404	0.0000000	1.2120000	0.00000
Iv4_807B	Ivanovice na Hane 4	1.4977915	1.0	2.647436	1.4285714	0.0000000	0.00000
Iv4_810	Ivanovice na Hane 4	126.4693416	41.5	31.658460	97.8571429	73.2873767	69.72465

11.0.1 Colophon

This report was generated on 2021-11-29 17:00:15 using the following computational environment and dependencies:

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#>  hash: page facing up, flying disc, oncoming police car
#>
#>  setting  value
#>  version  R version 4.1.2 (2021-11-01)
#>  os       Windows 10 x64 (build 19042)
#>  system   x86_64, mingw32
#>  ui       RTerm
#>  language (EN)
#>  collate  Danish_Denmark.1252
#>  ctype    Danish_Denmark.1252
#>  tz       Europe/Paris
#>  date     2021-11-29
#>  pandoc   2.14.0.3 @ C:/Program Files/RStudio/bin/pandoc/ (via rmarkdown)
#>
#> - Packages -------------------------------------------------------------------
#>  package          * version date (UTC) lib source
#>  abind              1.4-5   2016-07-21 [1] CRAN (R 4.1.0)
#>  assertthat         0.2.1   2019-03-21 [1] CRAN (R 4.1.1)
#>  backports          1.4.0   2021-11-23 [1] CRAN (R 4.1.2)
#>  bookdown           0.24    2021-09-02 [1] CRAN (R 4.1.1)
#>  boot               1.3-28  2021-05-03 [1] CRAN (R 4.1.2)
#>  broom              0.7.10  2021-10-31 [1] CRAN (R 4.1.1)
#>  cachem             1.0.6   2021-08-19 [1] CRAN (R 4.1.1)
#>  callr              3.7.0   2021-04-20 [1] CRAN (R 4.1.1)
#>  car              * 3.0-12  2021-11-06 [1] CRAN (R 4.1.2)
#>  carData          * 3.0-4   2020-05-22 [1] CRAN (R 4.1.0)
#>  cellranger         1.1.0   2016-07-27 [1] CRAN (R 4.1.1)
#>  class              7.3-19  2021-05-03 [1] CRAN (R 4.1.2)
#>  cli                3.1.0   2021-10-27 [1] CRAN (R 4.1.1)
#>  cluster            2.1.2   2021-04-17 [1] CRAN (R 4.1.2)
#>  codetools          0.2-18  2020-11-04 [1] CRAN (R 4.1.2)
#>  colorspace         2.0-2   2021-06-24 [1] CRAN (R 4.1.1)
#>  crayon             1.4.2   2021-10-29 [1] CRAN (R 4.1.1)
#>  crosstalk          1.2.0   2021-11-04 [1] CRAN (R 4.1.1)
#>  data.table         1.14.2  2021-09-27 [1] CRAN (R 4.1.1)
#>  DBI                1.1.1   2021-01-15 [1] CRAN (R 4.1.1)
#>  dbplyr             2.1.1   2021-04-06 [1] CRAN (R 4.1.1)
#>  DEoptimR           1.0-9   2021-05-24 [1] CRAN (R 4.1.1)
#>  desc               1.4.0   2021-09-28 [1] CRAN (R 4.1.1)
#>  DescTools        * 0.99.44 2021-11-23 [1] CRAN (R 4.1.2)
#>  devtools           2.4.2   2021-06-07 [1] CRAN (R 4.1.1)
#>  digest             0.6.28  2021-09-23 [1] CRAN (R 4.1.1)
#>  doParallel         1.0.16  2020-10-16 [1] CRAN (R 4.1.1)
#>  dplyr            * 1.0.7   2021-06-18 [1] CRAN (R 4.1.1)
#>  DT                 0.20    2021-11-15 [1] CRAN (R 4.1.2)
#>  e1071              1.7-9   2021-09-16 [1] CRAN (R 4.1.1)
#>  ellipsis           0.3.2   2021-04-29 [1] CRAN (R 4.1.1)
#>  evaluate           0.14    2019-05-28 [1] CRAN (R 4.1.1)
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#>  Exact              3.0     2021-09-02 [1] CRAN (R 4.1.1)
#>  expm               0.999-6 2021-01-13 [1] CRAN (R 4.1.1)
#>  factoextra       * 1.0.7   2020-04-01 [1] CRAN (R 4.1.2)
#>  FactoInvestigate * 1.7     2020-12-11 [1] CRAN (R 4.1.1)
#>  FactoMineR       * 2.4     2020-12-11 [1] CRAN (R 4.1.1)
#>  fansi              0.5.0   2021-05-25 [1] CRAN (R 4.1.1)
#>  farver             2.1.0   2021-02-28 [1] CRAN (R 4.1.1)
#>  fastmap            1.1.0   2021-01-25 [1] CRAN (R 4.1.1)
#>  flashClust         1.01-2  2012-08-21 [1] CRAN (R 4.1.1)
#>  forcats          * 0.5.1   2021-01-27 [1] CRAN (R 4.1.1)
#>  foreach            1.5.1   2020-10-15 [1] CRAN (R 4.1.1)
#>  fs                 1.5.0   2020-07-31 [1] CRAN (R 4.1.1)
#>  generics           0.1.1   2021-10-25 [1] CRAN (R 4.1.1)
#>  gglorenz         * 0.0.2   2020-05-27 [1] CRAN (R 4.1.1)
#>  ggplot2          * 3.3.5   2021-06-25 [1] CRAN (R 4.1.1)
#>  ggpubr             0.4.0   2020-06-27 [1] CRAN (R 4.1.1)
#>  ggrepel            0.9.1   2021-01-15 [1] CRAN (R 4.1.1)
#>  ggsci            * 2.9     2018-05-14 [1] CRAN (R 4.1.2)
#>  ggsignif           0.6.3   2021-09-09 [1] CRAN (R 4.1.1)
#>  gld                2.6.3   2021-11-24 [1] CRAN (R 4.1.2)
#>  glue               1.5.0   2021-11-07 [1] CRAN (R 4.1.2)
#>  gtable             0.3.0   2019-03-25 [1] CRAN (R 4.1.1)
#>  haven              2.4.3   2021-08-04 [1] CRAN (R 4.1.1)
#>  here             * 1.0.1   2020-12-13 [1] CRAN (R 4.1.1)
#>  highr              0.9     2021-04-16 [1] CRAN (R 4.1.1)
#>  hms                1.1.1   2021-09-26 [1] CRAN (R 4.1.1)
#>  htmltools          0.5.2   2021-08-25 [1] CRAN (R 4.1.1)
#>  htmlwidgets        1.5.4   2021-09-08 [1] CRAN (R 4.1.1)
#>  httpuv             1.6.3   2021-09-09 [1] CRAN (R 4.1.1)
#>  httr               1.4.2   2020-07-20 [1] CRAN (R 4.1.1)
#>  ineq               0.2-13  2014-07-21 [1] CRAN (R 4.1.0)
#>  iterators          1.0.13  2020-10-15 [1] CRAN (R 4.1.1)
#>  jsonlite           1.7.2   2020-12-09 [1] CRAN (R 4.1.1)
#>  kableExtra       * 1.3.4   2021-02-20 [1] CRAN (R 4.1.1)
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#>  later              1.3.0   2021-08-18 [1] CRAN (R 4.1.1)
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#>  lazyeval           0.2.2   2019-03-15 [1] CRAN (R 4.1.1)
#>  leaps              3.1     2020-01-16 [1] CRAN (R 4.1.1)
#>  lifecycle          1.0.1   2021-09-24 [1] CRAN (R 4.1.1)
#>  lmom               2.8     2019-03-12 [1] CRAN (R 4.1.0)
#>  lmtest           * 0.9-39  2021-11-07 [1] CRAN (R 4.1.2)
#>  lubridate          1.8.0   2021-10-07 [1] CRAN (R 4.1.1)
#>  magrittr           2.0.1   2020-11-17 [1] CRAN (R 4.1.1)
#>  MASS               7.3-54  2021-05-03 [1] CRAN (R 4.1.2)
#>  Matrix             1.3-4   2021-06-01 [1] CRAN (R 4.1.2)
#>  matrixStats      * 0.61.0  2021-09-17 [1] CRAN (R 4.1.1)
#>  memoise            2.0.0   2021-01-26 [1] CRAN (R 4.1.1)
#>  mice               3.14.0  2021-11-24 [1] CRAN (R 4.1.2)
#>  mime               0.12    2021-09-28 [1] CRAN (R 4.1.1)
#>  missMDA          * 1.18    2020-12-11 [1] CRAN (R 4.1.1)
#>  mnormt             2.0.2   2020-09-01 [1] CRAN (R 4.1.0)
#>  modelr             0.1.8   2020-05-19 [1] CRAN (R 4.1.1)
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#>  munsell          0.5.0   2018-06-12 [1] CRAN (R 4.1.1)
#>  mvtnorm          1.1-3   2021-10-08 [1] CRAN (R 4.1.1)
#>  nlme             3.1-153 2021-09-07 [1] CRAN (R 4.1.2)
#>  patchwork      * 1.1.1   2020-12-17 [1] CRAN (R 4.1.1)
#>  pcaPP            1.9-74  2021-04-23 [1] CRAN (R 4.1.1)
#>  pillar           1.6.4   2021-10-18 [1] CRAN (R 4.1.1)
#>  pkgbuild         1.2.0   2020-12-15 [1] CRAN (R 4.1.1)
#>  pkgconfig        2.0.3   2019-09-22 [1] CRAN (R 4.1.1)
#>  pkgload          1.2.3   2021-10-13 [1] CRAN (R 4.1.1)
#>  plotly         * 4.10.0  2021-10-09 [1] CRAN (R 4.1.1)
#>  png            * 0.1-7   2013-12-03 [1] CRAN (R 4.1.1)
#>  prettyunits      1.1.1   2020-01-24 [1] CRAN (R 4.1.1)
#>  processx         3.5.2   2021-04-30 [1] CRAN (R 4.1.1)
#>  promises         1.2.0.1 2021-02-11 [1] CRAN (R 4.1.1)
#>  proxy            0.4-26  2021-06-07 [1] CRAN (R 4.1.1)
#>  ps               1.6.0   2021-02-28 [1] CRAN (R 4.1.1)
#>  psych          * 2.1.9   2021-09-22 [1] CRAN (R 4.1.1)
#>  purrr          * 0.3.4   2020-04-17 [1] CRAN (R 4.1.1)
#>  R6               2.5.1   2021-08-19 [1] CRAN (R 4.1.1)
#>  RColorBrewer     1.1-2   2014-12-07 [1] CRAN (R 4.1.0)
#>  Rcpp             1.0.7   2021-07-07 [1] CRAN (R 4.1.1)
#>  readr          * 2.1.0   2021-11-11 [1] CRAN (R 4.1.2)
#>  readxl           1.3.1   2019-03-13 [1] CRAN (R 4.1.1)
#>  remotes          2.4.1   2021-09-29 [1] CRAN (R 4.1.1)
#>  reprex           2.0.1   2021-08-05 [1] CRAN (R 4.1.1)
#>  rlang            0.4.12  2021-10-18 [1] CRAN (R 4.1.1)
#>  rmarkdown        2.11    2021-09-14 [1] CRAN (R 4.1.1)
#>  robustbase       0.93-9  2021-09-27 [1] CRAN (R 4.1.1)
#>  rootSolve        1.8.2.3 2021-09-29 [1] CRAN (R 4.1.1)
#>  rprojroot        2.0.2   2020-11-15 [1] CRAN (R 4.1.1)
#>  rrcov            1.6-0   2021-09-16 [1] CRAN (R 4.1.1)
#>  rstatix          0.7.0   2021-02-13 [1] CRAN (R 4.1.1)
#>  rstudioapi       0.13    2020-11-12 [1] CRAN (R 4.1.1)
#>  rvest            1.0.2   2021-10-16 [1] CRAN (R 4.1.1)
#>  scales           1.1.1   2020-05-11 [1] CRAN (R 4.1.1)
#>  scatterplot3d    0.3-41  2018-03-14 [1] CRAN (R 4.1.1)
#>  sessioninfo      1.2.1   2021-11-02 [1] CRAN (R 4.1.2)
#>  shiny          * 1.7.1   2021-10-02 [1] CRAN (R 4.1.1)
#>  stringi          1.7.5   2021-10-04 [1] CRAN (R 4.1.1)
#>  stringr        * 1.4.0   2019-02-10 [1] CRAN (R 4.1.1)
#>  svglite          2.0.0   2021-02-20 [1] CRAN (R 4.1.1)
#>  systemfonts      1.0.3   2021-10-13 [1] CRAN (R 4.1.1)
#>  testthat         3.1.0   2021-10-04 [1] CRAN (R 4.1.1)
#>  tibble         * 3.1.6   2021-11-07 [1] CRAN (R 4.1.2)
#>  tidyr          * 1.1.4   2021-09-27 [1] CRAN (R 4.1.1)
#>  tidyselect       1.1.1   2021-04-30 [1] CRAN (R 4.1.1)
#>  tidyverse      * 1.3.1   2021-04-15 [1] CRAN (R 4.1.1)
#>  tmvnsim          1.0-2   2016-12-15 [1] CRAN (R 4.1.0)
#>  tzdb             0.2.0   2021-10-27 [1] CRAN (R 4.1.1)
#>  usethis          2.1.3   2021-10-27 [1] CRAN (R 4.1.1)
#>  utf8             1.2.2   2021-07-24 [1] CRAN (R 4.1.1)
#>  vctrs            0.3.8   2021-04-29 [1] CRAN (R 4.1.1)
#>  viridisLite      0.4.0   2021-04-13 [1] CRAN (R 4.1.1)
#>  webshot          0.5.2   2019-11-22 [1] CRAN (R 4.1.1)
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#>  withr             2.4.2   2021-04-18 [1] CRAN (R 4.1.1)
#>  xfun              0.28    2021-11-04 [1] CRAN (R 4.1.1)
#>  xml2              1.3.2   2020-04-23 [1] CRAN (R 4.1.1)
#>  xtable            1.8-4   2019-04-21 [1] CRAN (R 4.1.1)
#>  yaml              2.2.1   2020-02-01 [1] CRAN (R 4.1.0)
#>  zoo             * 1.8-9   2021-03-09 [1] CRAN (R 4.1.1)
#>
#>  [1] C:/Users/jsv399/Documents/R/R-4.1.2/library
#>
#> ------------------------------------------------------------------------------
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The current Git commit details are: